AD A095 302

AD-E400 555

SPECIAL PUBLICATION ARLCD-SP-80005

SECOND INTERNATIONAL CONFERENCE ON THE STANDARDIZATION OF SAFETY AND PERFORMANCE TESTS FOR ENERGETIC MATERIALS

RAYMOND F. WALKER
HAROLD J. MATSUGUMA
LOUIS AVRAMI

FEBRUARY 1981

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER
WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Date Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Special Publication ARLCD-SP-80005	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SECOND INTERNATIONAL CONFERENCE ON THE STANDARDIZATION OF SAFETY AND PERFORMANCE TESTS FOR ENERGETIC MATERIALS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Raymond F. Walker, H. J. Matsuguma, and L. Avrami		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS ARRADCOM, LCWSL Energetic Materials Division (DRDAR-LCE) Dover, NJ 07801		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS ARRADCOM, TSD Scientific & Technical Info Div (DRDAR-TSS) Dover, NJ 07801		12. REPORT DATE February 1981 13. NUMBER OF PAGES 109
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release, distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Standardization Safety tests Performance tests Interim qualification Acceptance tests	Explosives Propellants Pyrotechnics Chemistry Thermal tests	Hazards assessment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the minutes of the Second International Conference on the Standardization of Safety and Performance Tests for Energetic Materials which was held at ARRADCOM, Dover, NJ on 15-19 October 1979. The proposed outline of a standard manual was discussed. Discussion groups were established: Methodology, Chemistry, Safety, H.E. Performance, and Pyrotechnic Safety and Performance. Each group made recommendations which included tests and criteria for the assessment of safety and suitability of explosives (all energetic

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Contd)

materials) that would be required for the interim qualification of that material for military use. Submitted tests were categorized as mandatory, prescribed or optimal. A schedule was arranged for distribution and review of the specified group tests.

CONTENTS

INTRODUCTION

The following abbreviated minutes of the Second International Conference on the Standardization of Safety and Performance Tests for Energetic Materials, held 15-19 October 1979, are intended to provide an overall picture of the discussions and actions taken and proposed, to highlight the important points; and to provide a measure of continuity for future activities. The actual proceedings of the Conference will be a draft manual of tests to be used for the interim qualification of explosives. The list of attendees at the Conference is included in appendix A, and the meeting agenda in appendix B.

15 October 1979:

COL D.P. Whalen, Commander/Director, Large Caliber Weapon Systems Laboratory (LCWSL), U.S. Army Armament Research and Development Command (ARRADCOM), welcomed the participants and reinforced the need for continued international cooperation with respect to standardized tests and methodology for achieving common goals. He charged the confreres to do their best to achieve the objectives of the meeting and, thereby, contribute materially to maximum use of scarce R&D dollars.

The initial general discussion was devoted to the conduct of the Conference and to a review of the outline (appendix C) of the proposed manual of tests for interim qualification of energetic materials. The chairman of the meeting, Dr. R.F. Walker, Chief, Energetic Materials Division, LCWSL, ARRADCOM, gave the ground rules as follows:

1. There would be no formal presentations.

2. All participants would be involved in discussion groups which would deal with specific sections of the proposed manual.

Dr. Walker provided the background for this Second Conference, based on the first Conference held approximately two years ago at ARRADCOM, and subsequent activities in NATO, or under bi-lateral and other tri-service agreements.

Review of the Proposed Outline:

The proposed outline of a standard manual of tests was discussed in some detail. The proponent of this outline, the U.S., indicated that items 1, 2, and 3 of the outline are probably covered under the draft STANAG now being prepared by the UK and, therefore, the Conference would be concerned primarily with (appendix C) i.e., the interim qualification tests themselves. Further comment from the UK suggested that the meeting should concentrate on safety acceptance of materials and not be concerned too much with their application (final qualification in munitions). The UK representative pointed out that the STANAG being prepared is concentrated primarily on safety testing and not on methodology and performance. He also recommended strongly that the various study groups be selective in proposing various laboratory tests and be sure that the approach to proposing tests would involve answering the questions:

1. Why is the test required?

2. When is it required?

3. What does it answer?

It was further pointed out that it was unlikely that the Conference would be able to develop a set of "accepted" tests in a week and that, if the group could prepare a description and summary of what each nation does in the way of qualification testing, determine what sorts of test data are acceptable to all nations and, finally, what test data is mandatory in all nations, it would be a significant step forward in the establishment of a NATO manual. Finally, the UK indicated that it might be better to consider the manual to be an Allied Publication rather than a STANAG, which is a policy statement. The UK proposed that formal NATO numbers be obtained for the proposed document.

In response, Dr. Walker re-iterated comments made in the letters setting up the Conference, to the effect that the intent at this time was not to standardize on a single test for each measure of explosives safety or performance. Rather it was the intent to accept for inclusion in the manual (and without prejudice) all tests which nations use to assess or qualify their explosives for military use. The only condition was that the submissions provide sufficient description so that the nature of the tests, and the data provided by them, were understandable to other nations. The manual was conceived to be a "living" document, from which tests could be withdrawn or new tests inserted, as international agreement, usage, and technology advances required. The availability of standard reference explosive materials would facilitate the international interpretation of data.

These comments were generally accepted by the various delegations attending the meeting. Other national delegations suggested, for example, that the number of tests should be held to a minimum, the tests should not be excessively complex, methodology is an essential first step in any standardization approach, and criteria for passing or failing should also be standardized. It was pointed out that it would also be valuable if the kinds of tests required on an international exchange basis were fixed and that there be formal data packages provided to facilitate data exchanges. Here, also, a comment was made to support the contention that a set of standard materials for testing would be of great value in establishing an internationally accepted set of procedures. The spokesman from Sweden pointed out that the Scandanavian countries have a standardization group at work and that this group has found that one of the major problems is interpreting results from various sources. They also seconded the comment that reference materials are critical in exchanging information on energetic materials. It was evident that reference standards would, indeed, be valuable and that they would have to be well characterized. A standard tabulation of data on any material which is qualified for a specific application must also be maintained so that these data packages can be exchanged.

Establishment of Discussion Groups:

Next followed the setting up of discussion groups. The UK suggested groups to cover methodology, chemical properties, physical properties, biological properties, safety, and performance. They further suggested that the performance group be subdivided into groups concerned with initiators, main charges, gun propellants, and pyrotechnics. Further discussion then led to a combination of the physical properties and performance groups. The final list of groups involved methodology, which would be limited primarily to the delegation leaders; chemical, biological and safety properties; and physical properties and performance of initiators, main charges, gun propellants, and pyrotechnics.

It was recommended that the minutes of the First Conference on the standardization of tests be used as a point of departure for the working groups in the accomplishment of their tasks. Each group was reminded that its approach should deal with interim qualification and should not involve final qualification. Finally, the task areas of the various discussion groups were roughly defined as follows:

1. The Methodology Group was to be concerned with clarification of interim vs. final qualification and would review existing formal requirements with respect to international agreements in the form of STANAG's, etc.

2. The Chemical Group would be concerned with factors such as compatibility, stability, storability, compositional information, reference materials, and so forth.

3. The groups on Physical Properties and Performance of Explosives, Pyrotechnics and Gun Propellants would all be concerned with the determination of dimensional stability, thermal and mechanical properties, detonation velocity, fragment velocity, blast, luminous intensity, spectral emission, force, flame temp, erosivity, and other measures of output and performance.

4. The Safety Group would be concerned with safety tests such as sensitivity to various stimuli, initiation, vulnerability, and the like.

There was some discussion about the need for a Biological Properties Group, and it was decided that the group would not be needed. Topics relevant to this problem would be handled, as appropriate, in the other discussion groups. Each study group was reminded that its approach should be to focus on necessary and essential tests, not on tests which would be "nice-to-have."

16 October 1979:

The second day of the Conference included an initial general session wherein the responsibilities of the various groups were recapped, and each group was assigned a specific room in which to conduct its meetings. Following this brief general session, the discussion groups then met to conduct their assigned tasks.

17 October 1979:

The third day of the Conference was begun with a general session wherein the various group chairmen gave interim reports of the activities in their respective areas.

The Safety Group indicated that they had established the scope of the necessary tests in their area and gave a brief outline of the kinds of tests that they had discussed. They included tests which were already standardized and tests which were in development. There was, they pointed out, a lack of specific tests in the pyrotechnics and propellants safety areas, and this gap would have to be filled by further work. This group had received a large input and had requested documentation for each test that had been submitted.

The chairman of the Chemistry Group reviewed the progress made, indicating that they had established the scope of what were considered mandatory chemical tests. Questions were directed to the chairman of the group with regard to whether or not the Chemical Properties Group was going to cover tests evaluating the effect of storage on the mechanical properties of munitions systems, the dimensional and mechanical stability of explosives, and the effect of explosives on other materials. An additional question dealt with whether or not provision was going to be made for the testing of materials such as liquids and gels. The chairman noted these items for discussion in his group.

The report from the group on Physical Properties and Performance of Explosives was a listing of tests for high explosives, boosters and initiator materials, and a listing of physical, mechanical, and acoustic properties, where required. Although many excellent tests were described, no write-ups or formal procedures were provided. There were many tests for performance evaluation and, when asked about data on thermal and dimensional properties, the chairman indicated that such tests would be included by his group. The group was also discussing the need for standardized computational aids for the calculation of physical properties and physical performance characteristics.

The chairman of the Pyrotechnics Performance Group indicated that the group, although small, had made some progress, although there was a lot more to do. There were some clear test requirements, but, in many areas, these test requirements were not matched by good tests. For example, stability and performance vs. hygroscopicity are important and should be mandatory tests, but there are no good tests to measure these properties. The vacuum stability test is not really valid for pyrotechnics and better tests are needed for this and for ignitability. It was clear what mandatory information was required, but there were no tests suitable for obtaining this information. Considerable work remains to be done in this area. With regard to pyrotechnic performance, the situation was a little more positive and the group was attempting to define clearly what kind of data was required and to list the specific test which would provide the required data.

The Propellants Performance Group had not yet defined the scope of mandatory tests. There was considerable discussion on the test procedures available involving closed vessel burning rates, calorimetry, ballistics, and the like. The group had decided that proofing procedures were not applicable to interim qualification. The group also pointed out that JANNAF has a committee which is preparing a correlation between properties and behavior of propellants, and that it would be best to maintain close liaison with the JANNAF group and to utilize the output of that group as a point of departure for further work on the development of standardized tests for propellants. It was, therefore, proposed that the Propellants Performance Group not meet further. Since this was a very small group, and it really did not feel it could make any further progress during the Conference, the Conference Chairman accepted their suggestion.

The Methodology Group did not make a verbal report at this time, but circulated a typed summary of its deliberations to the chairmen of the other groups.

Following the morning session, the rest of the day was devoted to further discussions in the study groups and, since it was obvious that the study groups needed further time to complete their assigned tasks, the Conference Chairman specified that the morning of the fourth day would be devoted to the completion of the group discussions.

18 October 1979:

The general session on the afternoon of the fourth day was devoted to the summary reports of the discussion groups. The reports from the group chairmen constitute the body of this report.

The Pyrotechnics Properties and Performance Group described the progress that they had made toward the completion of their assigned tasks. They reported that they had identified needed safety and stability tests, but had been unable to define standard performance tests, although many tests were available to determine the same properties. In general, they concluded that work in this area still required considerable activity and that there was a long way to go to achieve the goals of standardized tests for pyrotechnics. If nothing else, they pointed out that it would be extremely worthwhile to interchange the specifications of the equipment and procedures now in use so that the various participants could then try to reconcile data that was exchanged.

The Explosives Properties and Performance Group summarized their discussions and described various required tests that had been defined. They pointed out that they had assumed that certain physical properties would be treated by other groups and that they had not spent any significant amount of time discussing such tests. It was further noted that many of the tests are device or munition specific, and it was possible that some tests were not worth standardizing because of this. For example, the performance of initiators was considered extremely device-oriented and, therefore, would probably not be mandatory in the true sense of the word.

The Propellant Properties and Performance Group repeated the discussion of the previous day, indicating that there is a great deal of work to be done in this area if we are to achieve any sort of compilation of safety and performance tests for propellants.

The Safety Group summarized their activity and indicated that they had developed tests for various stimuli and had specified which tests were to be written up and provided to the group. They had not treated toxicity, although they did indicate that data was required in this area for the qualification of a new material. They also identified specific gaps in safety testing. For example, there was a lack of tests specifically for pyrotechnics and propellants, there was a lack of information on the effect of temperature on the test results, there was a need for a proper format for presenting data in a useful and informative manner, and there was an obvious requirement for some tests to describe deflagration to detonation susceptibility of materials. The group was attempting to compile written documentation of the tests prescribed.

The chairman of the Chemical Properties Group described seven mandatory tests which had been established by the group. The write-ups describing these tests had been provided, with some exceptions, and the proponents of the missing tests had agreed to provide the written documentation as soon as possible. The group pointed out that some areas had not been covered in specific detail: for example, toxicity, environmental impact, and conformance with various sets of international regulations, but, since other groups with mission responsibilities and expertise in these areas were active, it was obvious that information in these areas, although required for interim qualification of substances, could better be obtained from the appropriate agencies.

The summary of the Methodology Group somewhat expanded, would probably comprise the introductory section for an international manual of standardized tests; it was recognized that individual countries may wish to provide supplementary material in their national editions of the manual, in order to clarify the methodology for their national users.

The remainder of the afternoon session was devoted to a discussion of other items which required attention. The first question centered around how best to proceed to insure that work on the international manual would continue and lead eventually to the formal establishment of such a document. It was pointed out that it would be very useful to utilize NATO channels in various countries both to demonstrate NATO backing and to strengthen support for the activities of the various national groups.

The national delegations were polled with regard to their interest in specific parts of the proposed manual and each delegation indicated its interest and its desire to participate in the work in the future. The Chairman of the Conference indicated that he would send the minutes of the Conference to his parent NATO organizations with a list of the participants, and let the NATO representatives decide formally how to distribute the manual and how to enlist formal participation in their respective countries. It was obvious that it would be necessary to keep energetic materials experts active in similar meetings and working sessions to support NATO operations toward developing a manual.

19 October 1979:

The final day's general session was devoted primarily to discussion of approaches to final qualification of munitions. It was pointed out that interim qualification must be consistent with the requirements of final qualification, which is tied strictly to specific munitions. Therefore, for final qualification, the tests and test conditions are normally a function of the munition and the environment in which the munition is expected to operate, and approaches and procedures in this area are not standard within NATO. It was agreed that inclusion of final qualification tests would not really serve a useful purpose at this time and was not within the scope of the meeting. Each national delegation provided a brief description of the procedure used within their countries for final qualification of munitions. It became clear that, as a rule, there are no formal manuals in use and that each nation tended to set up specific *ad hoc* groups to establish test programs for specific munitions, evaluate the data, require additional data when necessary, and then pass judgement on the acceptability of the munition in question. The only two nations which have established formal procedures are Sweden and the UK who, in essence, require specific information and documentation for evaluation of any munition in the final qualification procedure. Following this discussion, it was decided that it would be worthwhile to modify the summary developed by the Methodology Group to clarify the position of the Conference with respect to interim vs. final qualification.

It was also pointed out that the authorities in the respective nations who are responsible for interim qualification must be identified. The proposed manual must identify the authorities that grant interim qualification, and the repositories of interim qualification data.

The closing discussion was devoted extensively to the preparation of the manual and the issuance of minutes of the meeting. Since each discussion group chairman had provided a summary of his group's activities and a package of documented tests, where available, to the Conference committee, it was proposed that the Conference committee would first prepare and distribute a consolidation of these summaries and then prepare and distribute a draft manual drawing on the test descriptions collected at the meeting. Where tests had been identified but no write-ups submitted, there would be an appropriate gap if additional material is not submitted in the interim. The U.S. will undertake this task and will try to have a draft of the proposed manual out as soon as possible, probably within a matter of several months.

Dr. Walker indicated that during the next meeting of the NATO group of explosives experts, he would approach the NATO international staff to obtain formal NATO numbers and titles for the proposed STANAG on principles and the manual of tests.

GROUP REPORT - METHODOLOGY

Introduction

The development and selection of explosives for military use requires the careful balancing of several, often opposing criteria such as: performance on target, fuzing, vulnerability, safety, toxicity, storability, availability of ingredients, environmental impact, producibility, loading (filling), demilitarization, and cost.

It is the responsibility of the National Authority concerned to evaluate the effect of these criteria when determining whether a particular explosive is suitable for military use. However, there are certain data which have to be evaluated in a manner which is acceptable internationally to facilitate a disciplined transfer of data in support of the sale, transfer or collaborative development of weapons. These data are essentially the results of agreed safety tests, and of such performance tests as are sufficient to indicate that the material is suitable for consideration for its intended role.

Objective

The objectives of this document are:

1. To reference the data requirements for the assessment of safety and basic performance suitability of explosives for interim qualification for military use.

2. To catalogue the details of tests used by participating nations for each area of the data requirement.

3. To record the format for the transfer of data.

Scope

This document is concerned with the tests and criteria for the assessment of safety and suitability of explosives for military use. It is not a substitute for the legislative and regulatory requirements which are the responsibility of National Authorities. However, many of the safety tests catalogued in this manual may satisfy these legislative requirements.

Similarly, this document does not address the safety and performance data requirement for the acceptance of an explosive in a particular weapon application, which must be the subject of the Project Test and Evaluation Program.

Format

Section I lists the relevant standardization agreements which detail the agreed data requirements (including references to acceptable test methods.)

Section II is the catalogue of tests available within each participating nation, capable of providing the data requirements.

Section III is a list of reference explosive materials, to be agreed to by all participating nations.

Section IV is the format for recording and transfer of the data.

Section V is a glossary of terms.

Section VI is a list of National Approving Authorities.

Members

Dr. R.F. Walker, ARRADCOM, Chairman
COL G. Brace, UK
Dr. H. Passman, Netherlands
Dr. W. Schmacker, FRG
Dr. G. Perrault, Canada

GROUP REPORT - PYROTECHNIC SAFETY AND PERFORMANCE

The working group consisted of:

J.M. Jenkins, RARDE, UK (Chairman)
G.J. Litherland, NSWC, U.S.
F. McIntyre, NASA, U.S.
T. Boxer, ARRADCOM, U.S.
F. Taylor, ARRADCOM, U.S.
J. Tyroler, ARRADCOM, U.S.

Our first task was to identify tests which are additional to those advocated in the draft STANAG for the safety and stability of pyrotechnics. The tests have been listed in Table 1 and we have indicated those tests which the group considered should be mandatory even if they are not yet standardzed.

Performance Tests:

We were not able to identify many standard tests for the interim qualification of pyrotechnic compositions. Most pyrotechnics are tested in the final stage or end item configuration during the development of the composition.

The group adopted the policy of identifying the various pyrotechnic functions, e.g., illumination, color production, then listed those tests which are essential to define a particular function (Table 2), e.g., for a colored flare composition it is necessary to define its burning rate, luminous intensity (candle power), specific luminous flux (efficiency) and chromaticity coordinates. This was carried out for twelve different applications of pyrotechnic compositions.

The group then proceeded to consider tests for inclusion in the manual. However, it was rapidly realized that although many tests are carried out on pyrotechnics, most had not been written up as standard tests suitable for inclusion in a manual. These tests must be written up. There was considerable discussion on the problem of standardization of equipment, facilities and pyrotechnic test candles, but it was felt that at this time it would not be possible to get international agreement on standard tests. However, it is recommended that a serious attempt be made to standardize the specification and possibly the calibration techniques for the measuring equipment such as photometers and radiometers.

In order to achieve the two aims of writing-up the standard tests and standardizing the specification for measuring equipment, a considerable amount of effort and international collaboration will be necessary. The long term aim might be to define a series of internationally agreed tests in which the measuring equipment, environment of the burning store and the store itself, are standardized for inclusion in a manual. They need to be done. In many cases, it was felt that it would not be possible to get agreement on, or it would be impractical to carry out standard tests, e.g., for flares. Attempts have been made in the past to devise correction factors for tunnels and to use standard flares but these exercises have proved too complex. However, we recommend that attempts be made to use measuring equipment to standard specifications.

Table 1. Additional pyrotechnic safety tests to draft STANAG

Test Requirements	Recommended Status	Typical Tests	Remarks
Hygroscopicity	Mandatory UK MGAD	U.S. 303*	Similar and Satisfactory
Heat of combustion	Mandatory	MIL-STD 268-B Method 302.1 UK PP2	Similar and Satisfactory
TNT Equivalancy	Mandatory	TB-700-2	UK in Dev.
Bullet Impact	Desirable WR 50 USN No UK test	Method 107* EA4 D01	*ref.
Dust Explosion Composition and Constituents	Mandatory	Hartmann 1 cu. metre test 20 litre test	At present, not mandatory
Ignitability	Mandatory Bickford fuze test Radiation Pulse Test	UK Under Develop.	Not Discriminatory

Table 2. Pyrotechnic performance tests

Test Requirements	Rec. Status	Typical Tests	Remarks
Linear Burn Rate for Delays (steel tube), temp/press dependence	Mandatory	UK pp3 USN U.S Army	USN and Army have tests; need to be written up and submitted
Burning rate lined candle Bare grain	Mandatory	No standard test for composition	For flares, ultimately. No tests for standard lined candle. Test could be devised for extruded grain. Again, no standard
Candle power (candela)	Mandatory for photoflash, illuminants, etc.	No standard test for composition	Only end item tests carried out at present. Need to start with specification of tolerance on measuring equip. and calibration.

Table 2 (Continued)

Test Requirements	Rec. Status	Typical Tests	Remarks
Efficiency (candle/sec-kg)	"	"	"
IR Calibration Output	Mandatory	No standard test for composition	Only end item tests at present. Need to start by specification of detector and calibration
Chromaticity	Mandatory for colored flares	No standard test for composition	Begin standardization by specifying tolerances for equipment and type of equipment.
Tracer (Spin)	Mandatory for spin-stabilized projectiles	U.S., UK, Canada	Tests all related to spin rate and configuration of end item
High Pressure Vessel (gun breech simulator)	Mandatory for tracer	UK, Canada	U.S. Army; Navy does not test - go straight to gun firings of projectile
Smoke	Accept the KTA-8 Recommendations for Smoke		
Press/time Characteristics	Mandatory for expulsion charges and gun igniters	U.S. CB test UK MQAD	Test No. Req'd Test No. Req'd
Heat flux	Desirable for incendiaries	No typical test for composition for rocket motor igniter studies	Under development in U.S.. Used in UK
Chemiluminescence	Mandatory	No standard test	Need to standardize for time/intensity and spectral distribution

Test Papers Submitted at Conference

Hygroscopicity

Method 303 from U.S. EA4 D01 - submitted by F. McIntyre, NASA

Heat of Combustion

UK/Performance/Pyrotechnics/2 - submitted by J.M. Jenkins, RARDE, UK

Bullet Impact

Method 107 from U.S. EA4 D01 - submitted by F. McIntyre, NASA

Ignitability

UK Bickford Fuze Test - submitted by Safety Panel (Dr. K. Bascombe)

Linear Burn Rate for Delays

UK Pyrotechnic Performance/1 - submitted by J.M. Jenkins, RARDE, UK

Visible Emission from Pyrotechnic Flares

UK Performance Pyrotechnic/4 - submitted by J.M. Jenkins, RARDE, UK

IR Emission from Flares

UK Performance, Pyrotechnic/5 - submitted by J.M. Jenkins, RARDE, UK

Tracer

Spin

Valcartier, Canada

High Pressure Vessel

Pressure/Time Tests

D. Dillehay, Thiokol, U.S.

Test Papers that Need to be Included in Manual

Hygroscopicity

UK MQAD

Heat of Combustion

MIL-STD 268-B, U.S., Method 302.1

TNT Equivalency

TB-700-2, U.S.
UK test to be written up

Dust Explosion

Hartmann test - U.S., F. McIntyre, NASA
1 cubic metre test - Dr. H. Passman, Holland
20 litre test - Dr. H. Passman, Holland

Ignitability

Radiation pulse test - Dr. F. Taylor, ARRADCOM, U.S.

Linear Burn Rate for Delays

Dr. F. Taylor, ARRADCOM, U.S.
Mr. G.J. Litherland, NSWC, U.S. Navy

Candle power/Efficiency Tests

J. Tyroler, ARRADCOM, U.S.

IR Emission Measurement

J. Tyroler, ARRADCOM, U.S.
G. Litherland, NSWC

Tracer

High pressure vessel (gun breech simulator)
J.M. Jenkins, RARDE, UK

Pressure/Time Tests

J.M. Jenkins, RARDE, UK

GROUP REPORT - HE PERFORMANCE
W. K. BRISTOW, (Chairman)

Originally this group was asked to cover:

1. Physical Properties (Outline Manual, section IV, d)

2. Main Charge Performance (IV, F, 1, c)

3. Booster Performance (IV, F, 1, b)

4. Primary Performance (IV, F, 1, a)

It was found that there was considerable overlap with other groups in respect of (a), so that in order to avoid duplication, we have limited our discussions to those aspects of physical properties which are relevant to HE Performance although the UK has submitted a comprehensive set of tests.

Many of the performance tests are device-specific and there is little point in striving for a standardized version. This is particularly true for the following:

1. Performance of Deformed Charge: No test has been proposed for this.

2. Fragmentation: A test is submitted but is not expected to have a great deal of relevance (UK/Perf HE No. 5).

3. Shaped Charges: The performance is so sensitive to several dimensional parameters that optimization procedures are necessary for each new material. One test is submitted (UK/Perf HE No. 9), which provides some diagnostic information, but this is as yet in the developmental stage.

4. Primaries: Initiation tends to be very sensitive to design and manufacture so that all of these are submitted as prescribed tests. The UK have submitted 22 test descriptions relative to their usage.

Allocation of status is subjective in that a test which one person regards as mandatory will often be of interest to another. It is suggested that the editors of the manual be allowed scope to change these classifications upward in the light of the recommendations of other groups.

HE Performance Testing

<u>Combined Dent and Detonation Velocity</u>   <u>Mandatory</u>

W. Voreck, PATR 4780 (Attached)
M. Finger, LASL or LLL Version
J. Sorel, CEA France
W. Fox, LASL

Velocity of Detonation vs Diameter (Critical Diameter) — Mandatory

W. Voreck
M. Finger
J. Sorel
W. Bristow UK/Perf HE No. 1 (Attached)

C-J Pressure Determination — Mandatory

W. Bristow, UK/Perf HE No. 3 (Attached) (Manganin wire)
M. Finger
J. Sorel

Cylinder and Sphere Tests — Mandatory

For: Equation of state
C-J Pressure
Detonation Velocity
Gurney Constant
W. Bristow, UK/Perf HE No. 2 (Attached)
M. Finger

Flyer Plate, Head-On and Tangential — Optional

J. Sorel, CEA, France for Tangential (CB) test
M. Finger for Head-On

Unreacted Hugoniot Determination — Prescribed

LASI Test (also useful for input vs response data)
W. Bristow, UK/Perf No. 7

Corner Turning Test — Prescribed

M. Finger, LASL Test
J. Sorel, CEA, France

Underwater Test — Prescribed

W. Bristow, UK/Perf No. 4
J. Sorel, CEA, France

Detonation Calorimetry — Mandatory

M. Finger, LLL
J. Sorel, CEA, France

<u>Air Blast</u>	<u>Prescribed</u>
W. Bristow, UK/Perf HE No. 6 J. Sorel, CEA, France	
<u>Fragmentation Test</u>	<u>Optional</u>
W. Bristow, UK/Perf HE No. 5	
<u>Shaped Charge</u>	<u>In Development</u>
W. Bristow, UK/Perf HE No. 9	

Initiation Tests

<u>Minimum Booster Requirement Test</u>	<u>Prescribed</u>
W. Bristow, UK/Perf HE No. 8	
<u>Slapper Test</u>	<u>Prescribed</u>
W. Voreck (electrically driven slapper)	
<u>Gap Test</u>	<u>Mandatory</u>
Numerous tests available; see also Safety section	
<u>Wedge Test</u>	<u>Prescribed</u>
M. Finger, LASL and LLL Tests J. Sorel, CEA, France	

Calculation of Detonation Properties

<u>Computational Codes Available</u>	BKW
M. Finger, LLL	Forest Fire Tiger, etc

Determination of Physical Properties

Material Properties

Density and Bulk Density — Mandatory

D. Tisley, UK/Physical/1
D. Wiegand; J. Sorel, France
Mass/Volume, Gas Pricrometry, Crystallographic

Melting Point and Softening Behavior — Mandatory

D. Tisley, UK/Physical/2
D. Wiegand; J. Sorel, France
M.p. tube, Microscope Hot Stage, DSC

Specific Surface Area — Prescribed

D. Tisley, UK/Physical/3
D. Wigand; J. Sorel, France
Air permeability, gas absorption

Particle Size — Prescribed

D. Tisley, UK/Physical/4
D. Wiegand; J. Sorel, France
Sieving, sedimentation

Mechanical Properties

Compressive (UCS, Young's Modulus, Strain-to-Failure)

Static - UK/Physical/3 — Mandatory

Dynamic Yield Strength, — Mandatory

D. Wiegand, U.S.
J. Sorel, CEA, France

Tensile (UTS, Young's Modulus, Strain-to-Failure) Mandatory

Static - UK/Physical/4

D. Wiegand; J. Sorel, France

Compressive Creep — Prescribed

D. Tisley, UK/Physical/16
D. Wiegand; J. Sorel, France

<u>Shear</u> <u>Optional</u>

<u>Static</u> - UK/Physical/5

<u>Torsion</u> - D. Wiegand; J. Sorel, France

<u>Poissons Ratio</u> <u>Optional</u>

D. Tisley, UK/Physical/6

<u>Young's Modulus (Sonic Method)</u> <u>Optional</u>

D. Tisley - UK/Physical/7

<u>Three-Point Bend and Ring Tests for SupplementaryOptional</u>

<u>Tensile Data</u>

D. Tisley - UK/Physical/13 and 16 (Attached)

<u>Resonance Test</u> <u>Optional</u>

D. Tisley - UK/Physical/15

<u>Hardness Testing</u> <u>Optional</u>

D. Tisley - UK/Physical/17

<u>Impact Strength</u> <u>Optional</u>

D. Tisley - UK/Physical/18

<u>Viscosity Tests</u> <u>Prescribed</u>

D. Tisley - UK/Physical/19
D. Wiegand; J. Sorel, France

<u>Growth and Exudation Test</u> <u>Mandatory</u>

D. Wiegand and OD 44811
Test to be supplied by UK

<u>Hopkinson Bar Test</u> <u>Optional</u>

Details from M. Finger
J. Sorel

Thermal Properties

Linear Expansion — Mandatory

D. Tisley - UK/Physical/10
D. Wiegand; J. Sorel, France

Specific Heat — Mandatory

D. Tisley - UK/Physical/9
D. Wiegand; J. Sorel, France

Thermal Conductivity — Mandatory

D. Tisley - UK/Physical/8
D. Wiegand; J. Sorel, France

Thermal Diffusivity — Optional

D. Tisley - UK/Physical/11 — follows from 3.2, 3.2
D. Wiegand; J. Sorel, France

Tests in Development

UK/Physical Properties paper, pages 30-33.

Crumbling Test, e.g., for booster pellets, suggested but no write-up available. Currently not much of a UK problem since most boosters are tetryl. Could become a difficulty as part of the tetryl replacement program.

Initiator Performance

All tests are prescribed with the possible exception of Detonation Velocity and Gap Test. Other tests are device/usage dependent.

Reference to UK experts on flyleaf of attached paper.

Divisions made as laid out in table of contents, i.e.,

Mechanical		Electrical							
Input	Output	c.c.		Hotwire		EBW		Other	
		in	out	in	out	in	out	in	out

No details are available for UK/P/I/23.

W. Voreck suggests inclusion of the following:

1. Density, pressed density (covered by Physical Properties?).
2. Minimum Priming Charge (covered by Gap Test and UK/Performance/Initiator/10 but not per se).
3. Stab Sensitivity, Ball Drop, Air Gun (UK/P/I/3 and 4).
4. Effects of pressed density on sensitivity (implicit in UK/P/I 3 and 4).
5. Electrical input records, current and voltage (UK/P/I/11,15,18,20).
6. Function Time (UK/P/I/11,15,18,20).
7. Resistance (measured in some instances in UK but not in my paper).
8. Thermal Coupling (Rosenthal Method).
9. All fire and No fire levels (UK/P/I/11,15,18,20).
10. Output Fragment Velocity.
11. Output Plate Dent (UK/P/I/10 and some Gap Tests).
12. Output gap jumping ability (UK/P/I/14?).
13. Fragment pattern

Dead Pressing Susceptibility Test — Mandatory

Adopt test from OD 44811. Check needs to be made in UK to see if procedure is any different.

Min. Priming Charge Test — Mandatory

UK Detonant Test (UK/Performance/Initiator/10).

GROUP REPORT - PROPELLANT PERFORMANCE

Members: K.N. Bascombe UK
D. Hoffmans Netherlands

Joined by: A. Beardell, J. Vladimiroff, and J. Lannon of ARRADCOM for an informal discussion.

With only two members (both involved also in other groups) it is not surprising that the group made little progress with the question of "scope of mandatory tests" although it was noted that closed vessel testing is not mandatory in the U.S. as it is in the UK and the Netherlands. The U.S. is understood to consider that more reliable results can be obtained from proof.

The UK tabled 9 test procedures:

1. Ballistic Properties of Gun Propellants (Closed Vessel) (Stanag 4115)

2. Ballistic Properties of Gun Propellants at High Pressures (to 40 tsi)

3. 51 mm Mortar Test (modified closed vessel)

4. Rates of Burning of Double Base Proepllants

5. Rates of Burning of Composite Propellants

6. Rates of Burning of Propellants at High Pressures (to 20 tsi)

7. Rates of Burning of Double Base Propellants in 0.5 inch diameter strands

8. Calorimetry of Double Base Propellants

9. Internal Ballistic Parameters of Composite Propellants (2 inch rocket motor)

Of these, nos. 1,4,8, and 9 are established tests, the others being in various stages of development.

The Netherlands introduced a "chimney burner" test for strand burning of propellants, especially composite propellants; in this apparatus the corrosion of the burner by the combustion products is reduced by the employment of a continuous flow of inert gas. A procedure will be supplied for the manual.

A procedure for measurement of burning rates in 2-inch and 5-inch rocket motors was received from Canada.

The following was mentioned by the ARRADCOM representatives:

1. Calculations for modeling behaviour in closed vessels
2. 700 cc and 200 cc closed vessels
3. "Dynagun" to simulate gun conditions more accurately than closed vessels
4. High pressure closed vessel (for low temperature applications)
5. Ignition simulation- flame spread at pressures to 1000 psi (under development
6. Calorimetry test
7. Strand burning (not much used for gun propellants)

They also alluded to the following techniques for propllant ignitability.

1. arc-image furnace
2. hot wire
3. laser
4. DTA/DSC

These techniques appear to overlap with the safety field. There was also mention of a 5-second ignition test which must refer principally to stability.

Procedures will be provided for the manual.

Various problem areas were touched upon, as follows:

1. The selection of suitable computer codes for thermochemical modeling (Hirschfelder, Blake, NASA-Lewis)

2. The inconsistency of available thermochemical data

3. Inconsistent performance of the closed vessel

4. Difficulties with measurement of flame temperatures

5. Difficulties with measurement of pressures (static/dynamic)

6. Difficulties with assessment of combustion products

It was suggested that publication in the manual of the (adequately referenced) thermochemcial data used by the participating nations would help towards a solution of 2 above.

Physical testing of propellants was touched upon but not discussed in detail; again, test procedures are sought for the manual.

The subject of rocket propellants was not addressed.

Overall, there is evidently need for much further work in this area.

GROUP REPORT - SAFETY

The first order of business of the Safety Group was the selection of a chairman and secretary. The group chose L. Avrami, U.S., as chairman, and R.S. Lee, U.S., as secretary. The members of the Safety Group were as follows:

Louis Avrami, Chairman, U.S.
Ronald S. Lee, Secretary, U.S.
M. Finger, U.S.
Eric Olson, U.S.
Maurice Kirshenbaum, U.S.
Wayne Fox, U.S.
Manuel J. Urizar, U.S.
K.N. Bascombe, UK
Geoffrey Hooper, UK
Conrad Belanger, DREV, Canada
Jacques Brunet, SNPE, France
Jean Sorel, CEA, France
Manfred Held, MBB, Germany
Ton Schilperoord, TNO, Netherlands
Kiell Løvold, Norway
Per Wollert Johansen, DYNO, Norway
Stefan Lamnevik, Sweden

In order to decide on the scope of the mandatory tests to be included in the manual, the group agreed unanimously that the safety tests can be combined and be applicable to all explosives, propellants, and pyrotechnics.

The discussion on the safety tests to be performed began by considering the categories listed in the proceedings of the First Conference. The scope of the mandatory tests to be performed should include the following areas:

1. Impact

2. Friction

3. Thermal

4. Shock

5. Toxicity - Carcinogenicity

6. Electrostatic

7. Projectile Impact

8. Other - combined stimuli

The first attempt to list the safety tests related to impact began with each country stating its philosophy and methodology. The UK indicated that all of its safety tests were divided into three phases:

1. Accredited by committee

2. Done at one establishment, but accepted.

3. Under development.

The system in France is similar to that used by the UK. In the U.S. each service or agency uses the same precedure but only with explosives has there been tri-service accreditation of tests. Each agency accepts propellants and pyrotechnics based on end item testing. The Netherlands does not have any acceptance system. Germany indicated that it follows the methods used by the U.S. and NATO. Sweden stated that its method is similar to the United States. Canada uses the methods outlined by the UK and United States.

Each country then listed the Impact tests performed and the references describing the tests:

1. UK

	Name	Reference
a.	Small scale-Rotter Test	SSC-3 Tests #1, #17
b.	Initiating Materials - Ball and Disc	SSC-3 Test #14
c.	Liquid Impact Test	Under revision
d.	Spigot Test - PERME	Under development
e.	Spigot Test - AWRE	SCC-3 Test #24
f.	Oblique Impact Test	SCC-3 Test #16
g.	Explosiveness Test (AWRE)-LABSET	Under development
h.	Susan Test	SCC-3 Test #28
i.	RARDE Vertical Activator	Under development

2. France

The French representative indicated that France has a Standardization Group for HE Testing - GEMO, which is divided into two subgroups: a) Detonability Characteristics, and b) Sensitivity. A distinction is also made in impact tests between motionless and moving explosive samples.

	Name	Reference
a.	Julius Peters, BAM	FMD-410-A (Stationary)
b.	Bourges drop hammer	FMD-410-B
c.	Sorgues	FMD-410-C
d.	11 kg Drop Hammer (cast or pressed, unconfined)	FMD-410-D
e.	30 kg Test (propellants or HE)	FMD-410-F
f.	Hot Wire Impact (LABSOT)	FMD-410-G
g.	Low-velocity punch test	FMD-411-A (Stationary)
h.	High velocity punch test (gas gun)	FMD-411-B
i.	Lance Maquette Test (Bourges)	FMD-410-A (Moving)
j.	Susan Test	FMD-420-B
k.	Vertical Skid Test (45°)	FMD-420-C
l.	Pendulum Skid Test (14°)	FMD-420-D

3. Germany

   a. 5 kg BAM Test

   b. 10 kg BAM Test

4. Netherlands

   Same as Germany.

5. Sweden

   a. BAM Tests

   b. F.O.A. Setback Simulator

6. U.S.

The tests listed by the U.S. are in the Tri-Service Manual for Explosives or the TTCP Manual for Sensitiveness Tests.

a. Bureau of Mines (drop weight).

b. Picatinny Arsenal Impact (drop weight confined).

c. ERL (NOL, LASL, LLL) (different versions at different labs)

d. Ball Drop Test for Primaries (development)

e. Olin-Matheson Test for Liquids

f. 14° Pendulum Skid Test

g. Drop Skid Test (45° & 14°)

h. Spigot Test (AWRE)

i. Susan Test

j. Dahlgren Test (Navy, large scale drop)

k. PERME Test

l. Bureau of Explosives Drop Weight Test

m. RARDE Vertical Activator

n. Large Scale Impact

o. Yorktown Adiabatic Drop Weight (development)

7. Canada

a. Skid Test (14° drop)

b. Drop Hammer Impact Test (5 and 25 kg)

c. Setback Simulator (development)

The chairman stated that efforts will be made to obtain documentation for each test nominated and that each country should provide supporting documents for the tests proposed or indicate where the documentation may be obtained. Other candidate tests accredited or under development, can be submitted for the final draft.

For the Friction category the following tests were submitted by country:

1. UK

a.	Mallet Friction Test	SCC-3 Test #2
b.	Rotary Friction Test	Development
c.	Emery Paper Friction Test	SCC-3 Test #13
d.	Stab. Sensitivity Test	Development
e.	AWRE Oblique Impact	SCC-3 Test #16

2. Canada

   a. Oblique Impact - AWRE

3. France

a.	Julius Peters Friction Test (BAM)	FMD-430-A
	(1) Primary	
	(2) Secondary	
b.	Rotary Friction Test	Under Development

4. Germany

a.	BAM Friction Tests	Primary & Secondary

5. Netherlands

a.	BAM Friction Tests	Primary & Secondary
b.	Pressure, Sliding Friction Test	Development

6. Norway

a.	BAM Friction Test	Secondary
b.	ABL Friction Tester	

7. Sweden

a.	BAM Friction Tests	Primary & Secondary
b.	Steel and Stone Friction Test	Development
c.	Nut and Bolt Test	Development

8. U.S.

   a. Picatinny Arsenal Friction Pendulum Test

   b. NOTS Pendulum Test

   c. BAM Tests — Development

   d. ABL Friction Test — Development

   e. Dupont Sliding Rod Test — Development

   f. Skid Test

   g. Pantex Snatch Friction Test — Development

   h. Thiokol Strip Friction Test — Development

For the Electrostatic Sensitivity Category, the following tests were submitted by country:

1. UK

   a. Electric Test — SCC-3 Test #6

   b. Electric Spark Test for Sensitive Explosives — SCC-3 Test #7

2. Canada

   None

3. France

   a. Bourges A — FMD-450-A

   b. ATS-SNBE B — FMD-450-B

4. Germany

   Nothing Standardized — Development

5. Netherlands

   a. Bureau of Mines, fixed gap

6. Norway

   a. CMI Test — Development

7. Sweden

   a. FOA Fixed Gap Bureau of Mines

8. U.S.

   a. Fixed Gap, Bureau of Mines

   b. Approaching Electrode - UK

   c. Approaching Electrode - U.S. — Development

   d. Confined Electrode, Approaching Electrode — Development

   e. Fixed Gap (NSWC)

For Shock Initiation the following tests were submitted for each country:

1. UK

a.	Small Scale Gap Test (Aldermaston)	SCC-3 Test #18
b.	Small Scale Gap Test (PERME-RARDE)	SCC-3 Test #11
c.	Large Scale Gap Test (NOL)	SCC-3 Test #22
d.	PERME F-1 Gap Test (pressure gauges)	SCC-3 Test #23
e.	PERME Scale IV Gap Test (liquids)	SCC-3 Test #15
f.	PERME-LASI	Development
g.	Propagation of Detonation (liquids, slurries, etc)	SCC-3 Test #19

2. Canada

a.	Large-Scale Gap Test	
b.	Flying Plate Test	Development

3. France

a.	Flying-Plate Test	FMD-470
b.	Card-Gap Test	
c.	Electric Flyer Plate	Development

d.	Small-Scale Gap Test (LASL)	Development
e.	Corner-Turning Test	Development
f.	Minimum Initiating Charge	Development

4. Germany

No standardized gap tests.

a.	Small Scale Gap Test	Development
b.	Large Scale Gap Test	Development
c.	Corner Turning	Development

5. Netherlands

a.	NOL Large-Scale Gap Test	
b.	BICT Small-Scale Gap Test	Development

6. Norway

a.	Air Gap Test	Standard

7. Sweden

a. NOL Small Scale Gap Test

b. FOA Minimum Priming Charge Test

8. U.S.

a.	Bureau of Mines Large-Scale Gap Test	
b.	NOL Large-Scale Gap Test 2"	
c.	NOL Small-Scale Gap Test 0.2"	
d.	LASL Large-Scale Gap Test 1.625"	
e.	LASL Small-Scale Gap Test 0.5"	
f.	LASL Medium-Scale Gap Test 1.0"	
g.	Picatinny Small Flying Foil	Development

4. Germany

a. 7.62 mm projectile impact (unconfined) — Development

(1) normal (lead)

(2) steel core

(3) tracer

Charge is lightly confined in a 10 cm x 10 cm x 0.5 mm steel box.

b. 5 cm x 5 cm x 5 mm steel casing. (steel core impact) — Development

c. Normalized impact. 50 mm diameter copper projectile. Find velocity threshold for detonation. (unconfined charge) — Development

d. RATTAM Test 7.62 steel core proj. 12.7 mm projectile, 20 mm HE projectile, 84 mm HEAT shaped charge. (Carl Gustav) — Development

e. Embedded Projectile Test 7.62 mm (3 type)

5. Netherlands

No Standardized Projectile Test.

6. Norway

Swedish Projectile Test.

7. Sweden

15 mm Flat Projectile Test (brass)

8. U.S.

a. .30 cal bullet

b. .50 cal projectile

c. Navy Sensitivity to Frag. Impact Test .50 cal - steel bullet

d.	Fragment Impact Test	Development
e.	Gas-Gun Projectile Tests (multiple projectiles and targets)	Development
f.	.30 cal to 30 mm bullet impact	
g.	Right circular cylinder tests	
h.	Large target impact (embedded)	
i.	DuPont Projectile Test (19 mm)	

Fragment

1. UK

   None

2. Canada

   None

3. France

   None

4. Germany

   No uniform test

5. Netherlands

   None

6. Norway

7. Sweden

8. U.S.

a.	Jet-Induced Fragment Attack	Development
b.	Fragment-Initiation of Propellants	Development
c.	Multi-Fragment Impact Test LLL	Development

Jet

U.S.

LASL Jet Sensitivity — Development

Although the group realized that Thermal tests may be considered by another group, it believed that Thermal tests still are a form of safety tests. The submissions of each group should be received in order to encompass all the proposed tests. The following tests were submitted by each country:

Thermal:

1. UK

a. Temperature of Ignition Test 5°C/min	SCC-3 Test #3
b. Bickford Fuze Test	SCC-3 Test #4
c. Train Test	SCC-3 Test #5
d. RARDE Burning Tube Test	Development
e. Large Scale Vessel Test (2 L)	SCC-3 Test #10
f. Small Scale Vessel Test (5 mL)	SCC-3 Test #9
g. Minimum Ignition Energy Test	Development
h. Standard Liquid Fuel Fire Test	SCC-3 Test #25

2. Canada

   a. Temp of Ignition Test

   b. Bickford Fuse Test

   c. Train Test

   d. DTA, DSC, TGA

4. France

   a. Induction Time Constant Temp. — FMD-440

   b. Temp. of Ignition

   c. DTA Analysis, DSC, TGA

d. LABSET Hot Wire

e. BAM External Heating

f. Cook-off Test

g. Induction Time by Progressive Heating (large scale)

h. Fuel Fire Test

i. ODTX

j. Unconfined Burn Test (train test)

4. <u>Germany</u>

a. Induction Time, Const. Temp

b. Temp. of Ignition

c. DTA, DSC, TGA

d. BAM External Heating

e. Fuel Fire Test

f. Cook-off

g. Reaction by given Heat Capacity Fragment

5. <u>Netherlands</u>

a. BAM External Heating

b. Thermal Explosion Test with Pressure Measurement — Development

c. DTA, etc.

d. Isothermal Storage Test

e. Adiabatic Storage Test

f. Thermal Step Test — Development

g. DDT Test similar to NOL — Development

6. Norway

   a. BAM Test

   b. DTA, etc.

   c. Large Sample Temperature of Ignition

7. Sweden

   No standard Tests

   a. DTA, etc.

   b. Temp. of Ignition

   c. BAM Test

8. U.S.

   a. Unconfined Burn Test

   b. DTA, etc.

   c. Temp. to Explosion (confined)

   d. Temp. to Explosion (unconfined)

   e. Heat Test for Propellants

   f. Oven Test TB 700-2

   g. Bonfire Test

   h. ODTX — Development

   i. Cook-off Test — Development

   j. Fuel Fire

   k. DDT — Development

   l. Henkin Test

   m. Auto-Ignition Temp.

With reference to Toxicity and Carcinogenicity the consensus of the group was to include a statement that available toxicity and carcinogenicity data on an explosive composition and its products should be included in data describing the hazard potential of that explosive. Contact should be made with the appropriate agencies to obtain pertinent information.

Under the category of Other Tests, the following tests were submitted by the respective countries:

1. UK

   a. Free-Fall Test — SCC-3 Test #27

   b. Proof Machining Test — SCC-3 Test #26

2. Canada

   None

3. France

   a. Dry Drilling Test for 3 mm and 10 mm Diameter Tools — FMD-490-A

   b. Extrusion Test for Pressed Explosives — FMD-490-B

4. Germany

   None

5. Netherlands

   None

6. Norway

   a. Critical Diameter, Confined & confined

7. Sweden

   None

8. U.S.

   a. DARCOM Reg 385-100 for Machining and Pressing

   b. LASL High Speed-Machining Test

   c. LASL General Machining Tests

   d. Fragment Attack Tests

   e. Radiation Effects (Ionizing)

   f. EM Radiation Effects

General Statement: Depending on end use, these safety tests should be conducted over a range of parameters that can affect the outcome of the tests, e.g., temperature and pressure.

In the general discussion that followed on the scope of the mandatory tests for energetic materials, the group was not clear on what was desired. It was suggested that the questions posed in the proposed draft STANAG from the UK be used for a start (appendix D). It was decided that each national group would answer the questions in the proposed STANAG and these responses would be combined. Each nation was encouraged to add additional questions to the list for consideration by the group.

Appendix D also includes the tests submitted by each country for each type of energetic materials. Additional inputs were submitted by DOE and DARCOM Field Safety Activity.

Appendix E lists the final form of the questions approved by the group. Each question is ranked to reflect either mandatory or optional data.

The final item discussed by the Safety Group was whether or not the meeting agenda left any gaps. These considerations can be summarized by the following:

1. What is the effect of temperature on the safety tests? - Question addressed to a perceived gap in our understanding.

2. What are the rates associated with deflagration phenomena? - Gap in understanding.

3. Do the proposed tests cover the relative parameters and are some over-represented?

4. Need for complete data format including standard material test results.

It was suggested that an article by Stig Ek, "Sensitivity of Explosive Substances - A Multivariate Approach", 6th Detonation Symposium, pp. 272-280, might shed some light on (3) above.

GROUP REPORT - CHEMISTRY

The countries which participated in the meeting of the group and their principal delegates were as follows:

Canada - Dr. Guy Perrault

Germany - Dr. Alex Dellmeier, Dr. D.C. Herborg, Dr. W. Merten, Dr. T. Rosendorf, Dr. W. Schmacker, and Dr. F. Volk

Netherlands - Dr. D.W. Hoffmans and Dr. H. Pasman

United Kingdom - Mr. N.J. Blay (Chairman), Mr. D. Meade (Secretary)

United States - Dr. H. Matsuguma, Dr. Tillman Richter

The group considered those submissions to the previous Conference, which had dealt with chemical problems, mostly of stability or storability. We found that they were, in general, concerned with development of new test procedures and that there would be no overlapping with the business of the present Conference.

The group was tasked to review the various test methods described in submissions to the conference and other known methods and to consider their merit and applicability to the various chemical requirements which are part of the Explosives Qualification process.

We identified the following mandatory requirements:

1. Stability

2. Storability and Assessment of Life

3. Compatibility

4. The specification of explosives in respect to chemical composition and properties. This includes methods of analysis.

5. The need for an explosive to conform to current regulations and its classification.

6. Toxicity

7. Environmental Impact

The group was able to deal with only the first four of these topics, discussion of the remainder going no farther than attempts to define them.

Stability Tests

From the outset it was evident that time was not available for the group to adequately discuss the merits or weaknesses of all the many stability tests which are used on energetic materials. It was more approprite to:

1. List the tests.

2. Establish for which classes of energetic materials they were considered appropriate.

3. Discuss certain features and developments in respect to the more important of them.

4. Distinguish between the more important (prime) tests, the lesser important (supplementary) tests, and new tests still under development.

5. Obtain the opinion of group members as to their value.

The more important (or prime) tests and their applications are listed in Table 1 and supplementary tests and those under development are listed in Table 2. Differences in procedures for performing essentially similar tests were not considered at this stage and there were only short technical discussions. A presentation by Dr. Volk entitled "A Fast Method for Measuring the Life-Time of Propellants" described work related to the German 90°C Surveillance Test (Thin Layer Chromatography).

Important comments regarding some of the prime tests were as follows:

1. Vacuum Stability Test - The apparatus for this test is not subject to modification to allow the use of pressure transducers for the measurement of the evolved gases. This has already taken place in the UK and is under active consideration in some other countries. The performance of explosives in the test is not significantly altered provided that the total internal volume of the apparatus remains the same.

Satisfactory performance in the test is a mandatory requirement in the qualification of new explosives of all types in the U.S.. Other countries consider it as a prime test for high explosives and boosters but, in most cases, only as a supplementary test for propellants. They do not, as a rule, regard it as very useful for pyrotechnic or primary explosives.

2. Abel Heat Test (Potassium Iodide - Starch Test) - This is the principal test used in the UK for inspecting propellants and failure to perform normally in it would be an obstacle to qualification of a new composition. When the characteristic behavior of a propellant composition in the test has been established and test limits have been fixed, propellants passing the test are with confidence judged as stable. The principal weakness of the test is that it occasionally gives false indications of instability, and recourse to more lengthy methods must then be made. In most countries the test is important for confirming the stability of nitroglycerine and in some cases nitrocellulose. There are, however, significant differences in the procedures which are used, particularly for nitrocellulose.

3. Bergmann & Junk Test - The most important application of this test is for nitrocellulose. It is also used in Germany for propellants and in France for propellants and pentaerythritol tetranitrate. The German method employs a Schultze-Tiemann type finish to measure the extent of decomposition at the end of the test.

4. 80°C Silvered Vessel Test - This long-estabished test has been used in the UK to obtain results which can be related to those from other propellants and which indicate the ability of the propellant to withstand prolonged hot storage. Germany has also used a similar test. Alternative more modern

techniques, such as Heat Flow Calorimetry will probably supersede this test in due course.

5. Temperature of Ignition Test - This is usually regarded as a safety test but is also an indication of composition stability. Extremely high results in the test, e.g., more than 300°C, are often regarded as sufficient proof that the explosive (usually pyrotechnic) will be satisfactorily stable at normal temperatures under dry conditions.

6. Change in Composition (in presence of moisture) - Tests in this group study the stability of explosives, particularly primary explosives and pyrotechnic compositions, under moist accelerated aging conditions. The reason for their use is that experience has shown that moisture has almost invariably been an essential factor in any problem of instability which has arisen with these classes of explosive. Changes in the explosive are detected by chemical or thermal analysis or by other appropriate means.

7. 90°C Surveillance Test (Thin Layer Chromatography) - This test for propellants has been introduced by Germany. It uses analysis by thin layer chromatography to assess stability from the nature and quantities of propellant stabilizers and their derivatives which remain after a period of aging of one week at 90°C.

8. Dutch Weighing Test - This test is standard in the Netherlands and is required by their inspection and surveillance procedures.

Each of the "prime" tests (Table 1) was considered in respect of its general acceptability. Members of the group were asked to indicate, whether in their opinion, the authorities in their countries would give significant support of qualification of their energetic materials. Although members spoke as national groups it is emphasized that these were ad-hoc opinions, not representing final, national, view-points. They do, however, indicate the extent of consensus of opinion which already exist.

The opinions are included in Table 1. The U.S. and German members of the group said that they thought that their countries would recognize the validity of all the tests as being capable of providing useful data and Table 1 reflects this point. Only the U.S. designated several tests as being mandatory.

Uncertainty as to the procedures used, hindered comment from some countries in regard to the Exudation of U.S. Self Heating Tests.

Extension of this exchange of method assessments, could reduce the difficulties which arise when qualification data for explosives has to be exchanged between countries. In this connection, there is obvious merit in tests which require comparatively simple or standard equipment and procedures and which can, therefore, be performed relatively easily in other countries.

Storability Tests (Table 3)

Many of the stability tests already considered apply equally to storability and the assessments already presented in Table 1 mostly apply. Additional information concerning properties other than chemical stability is necessary before storability of an explosive can be judged and these properties are listed in the latter part of Table 3. Few methods to test for these properties have been presented and the markings given in Table 3 mostly indicate merely that information concerning them is required in the qualification process.

Compatibility Tests

Compatibility tests, prime, supplementary and those under development are listed in Table 4 with opinions and status indications.

Mr. Blay (UK) reported on the present status of NATO STANAG 4147 (Chemical Compatibilty of Ammunition Components with Explosives & Propellants - Non Nuclear Applications). At a meeting in the UK on 2 and 3 August 1979, amendments to the STANAG had been agreed which should satisfy the objections which the U.S. had made to the original version. These objections had mostly concerned the details procedure given for the Vacuum Stability Test.

Experience had shown that the most difficult problems in drafting STANAG 4147 arose in agreeing to the details of the procedure for the Vacuum Stability Test. The prospects of obtaining similar agreements on other tests within a reasonable time were poor and the UK had proposed and had undertaken to provide, a new Annex to the STANAG which presents the principles governing acceptable tests. The revised draft of the STANAG, currently being circulated, includes this Annex which will require much discussion and probably amendment before an agreement version emerges.

Apart from chemical compatibility tests on explosives other aspects of compatibility problems were mentioned as follows.

The problem of identifying and agreeing, which components of ammunition need to be tested.

This appeared to be defined satisfactorily in the German document TL 1376-800, section 1.5.1. An English translation of this statement is as follows:

> "The inert substances contained in explosives and explosive compositions have to be compatible, chemically and physically, with each other and with the explosive constituents.
>
> The requirement for inert substances applies also to materials which are in contact, or could come in contact, with explosives during production, transport, and processing.

Contact, and possible contact, with explosives are defined as follows:

- direct contact
- gas diffusion or surface diffusion
- penetraton through interfaces and casing walls.

Concerning diffusion and penetration, the process of migration can originate in either the explosive or the inert substance."

The problems of physical incompatibility and the effects both chemical and physical which explosives may have on other materials were not addressed in detail. The need to avoid these incompatibilties is obvious.

The need for adequately specifying materials which have to be compatible with explosives is dealt with the Annex B of STANAG 4147. Without such specifications repeated testing of new supplies of materials becomes necessary with consequent expense and delay.

Specifications

An adequate specification is essential for a properly qualified explosive, and the group considered what clauses governing chemical and physico-chemical properties were necessary.

The following list was compiled:

1. Composition details with tolerances on proportions of ingredients.

2. References to specifications for ingredients.

3. Methods of analysis required to perform the specification tests with information on accuracy and reproducibility. The tolerance limits in the specification must be consistent with this information.

4. Permitted impurity levels, e.g., volatile matter, water, trace elements, acidity/alkalinity, etc.

5. Other requirements may define or limit.

Color	
Odor	
Melting Point	
Setting Point	
Refractive Index	As appropriate
Particle size and distribution	
Density	
Porosity	
Crystal Polymorphism	
Method of Manufacture	

Conformity to Regulations

This subject was introduced because it did not appear to have been considered elsewhere in this forum. With the growing multiplicity of storage, transport, and other regulations which now exist, difficulties in qualification could arise if required tests were omitted or could not be satisfied. The composition of the present group and the available time did not allow further discussion.

Toxicity

The group was not qualified to discuss this matter but its importance was recognized.

Environmental Impact

During a brief discussion it was said that the impact of an explosive on the environment can manifest itself during:

1. Manufacture
2. Storage and handling
3. Use, including proofing, testing, and training
4. Demilitarization

Each of these circumstances may introduce different problems but specialist advice beyond that present in this Conference will be needed before the subject can be proceeded with.

Reference Materials

The group was tasked to consider problems which would arise in the provision of standard energetic materials to which reference could be made particularly in the context of standardized safety test procedures. Two courses of action were mentioned.

1. The setting aside of suitable stocks of reference standards from which supplies could be provided to the participating nations and laboratories.

2. The drafting of closely defined specifications which would enable materials of sufficiently consistent quality to be produced in a number of places.

The extreme difficulty and great expense of transferring explosive materials samples was stressed and it was agreed that method 1 should only be adopted if method 2 failed. The point was also made that generalization was impossible and that different explosives would present different problems and requirements.

Identifiable Gaps in Information

Apart from topics already mentioned which received scant attention two classes of energetic materials were not discussed. These were composite or rubbery propellants for which Canada was the only country to submit test information and nonsolid energetic materials which received no mention at all.

Information from other nations is required to complete the presentation in the Tables of this report; and promises to supply further test descriptions were made by several members of the group.

APPENDIX A

ATTENDEES

L. AVRAMI
US Army Armament Research and
Development Command
LCWSL
Dover, NJ 07801

K.N. BASCOMBE
Propellants, Explosives and
Rocket Motor Establishment
Powdermill Lane
Waltham Abbey, Essex EN9,. 1BP, England

K. BEEDHAM
Ordnance Board
Charles House
Kensington High Street
London, W.14, 8QP, England

C. BELANGER
Defense Research Establishment Valcartier
C.P. 880, Courcelette
Valcartier, Que, Canada, GOA 1RO

N. BLAY
Propellants, Explosives and
Rocket Motor Establishment
Powdermill Lane
Waltham Abbey
Essex EN9, 1BP, England

T. BOXER
US Army Armament Research and
Development Command
LCWSL
Dover, NJ 07801

COL. G.G.W. BRACE, RM
Ordnance Board
Charles House
Kensington High Street
London, W.14, 8QP, England

MR. BRISTOW
Atomic Weapons Research
Establishment
Foulness, England

J. BRUNET
Societe Nationale des Poudres et
Explosifs
Centre de Recherches du Bouchet
Le Bouchet
91710 Vert-Le-Petit, France

M. FINGER
Lawrence Livermore Laboratory
P.O. Box 808
Livermore, CA 94550

WAYNE P. FOX (MS-920)
Los Alamos Scientific Laboratory
University of California
P.O. Box 1663 Los Alamos, NM 87545

M. HELD
Messerschmitt-Bölkow-Blöhm GMBH
Postabholfach, 8898 Schroberhausen
Federal Republic of Germany

D. W. HOFFMANS
Prins Maurits Laboratory TNO
Technological Research
POB 45, 2280 AA Rijswijk
The Netherlands

G. HOOPER
Defence Equipment Staff
British Embassy
3100 Massachusetts Avenue, NW
Washington, DC 20008

J. JENKINS (RARDE/EM3)
Royal Armament Research and
Development Establishment
Fort Halstead, Sevenoaks
Kent, England

M. KIRSHENBAUM,
US Army Armament Research and
Development Command
LCWSL
Dover, NJ 07801

D. KOGER
USA ARRADCOM
NASA-NSTL
NSTL Station, MS 39529

STEFAN LAMNEVIK
National Defense Research Institute
Dept. 2, FACK
S-104 50, Stockholm, Sweden

RONALD LEE
Lawrence Livermore Laboratory
Dept. of Physics
Kansas State University
Manhattan, KS 66502

B. LITHERLAND
Naval Weapons Support Center
Code 5045
Crane, IN 47522

K. LØVOLD
DYNO Industries A.S.
Gullaug Fabrikker
P.B. 1076
3001 Drammen, Norway

H. MATSUGUMA
US Army Armament Research and
Development Commnd
LCWSL
Dover, NJ 07801

FRED MC INTYRE
Computer Science Corp.
NASA National Space Technology
Laboratories
NSTL Station, MS 39529

D. MEAD
MQAD
Woolwich, England

W. MERTEN (BWB, WM I 3)
Bundesamt für Wehrtechnil und
Beschaffung-BWB
Konrad-Adenauer-Ufer 2-6
D-5400 Koblenz
Federal Republic of Germany

E. OLSON
US Army Materiel Development and
  Readiness Command
Field Safety Activity
Charlestown, IN 47111

H.J. PASMAN
Prins Maurits Laboratory TNO
Director Technological Research
POB 45, 2280 AA Rijswijk
The Netherlands

G. PERRAULT
DREV, C.P. 880, Courcelette
Quebec, Canada GAOIRO

T. RICHTER
US Army Armament Research and
  Development Command
LCWSL
Dover, NJ 07801

T. ROSENDORFER
Messerschmitt-Bölkow-Blöhm GMBH
MBB Apparate
Postabholfach, 8898 Schrobenhausen
Federal Republic of Germany

A. A. SCHILPEROORD
Prins Maurits Laboratory TNO
Technological Research
Head Section Detonation
POB 45, 2280 AA Rijswijk
The Netherlands

W. SCHMACKER (BWBWM IV 2)
Bundesamt für Wehrtechnik und
  Beschaffung-BWB
Kinrad-Adenauer-Ufer 2-6
D-5400 Koblenz
Federal Republic of Germany

J. SOREL
French Atomic Energy Commission
CEA-Establissement T
Boite Postale 7, 93270

F. TAYLOR
US Army Armament Research and
  Development Command
Dover, NJ 07801

D. TISLEY (RARDE/EM1)
Royal Armament Research and
Development Establishment
Fort Halstead, Sevenoaks
Kent, England

J. TYROLER
US Army Armament Research and
Development Command
LCWSL
Dover, NJ 07801

MANUEL J. URIZAR (MS-920)
Los Alamos Scientific Laboratory
University of California
P.O. Box 1663
Los Alamos, NM 87545

F. VOLK
Institut fur chemie der Treib- und
Explosivstoffe der Fraunhofer-Gesellschaft
7507 Pfinztal-Berghausen
Postfach 40, Germany

W. VORECK
US Army Armament Research and
Development Command
LCWSL
Dover, NJ 07801

R. WALKER
US Army Armament Research and
Development Command
LCWSL
Dover, NJ 07801

D. WIEGAND
US Army Armament Research and
Development Command
LCWSL
Dover, NJ 07801

PER WOLLERT-JOHANSEN
DYNO Industrier A.S.
P.B. 1076
3001 Drammen, Norway

APPENDIX B

AGENDA

SECOND INTERNATIONAL CONFERENCE ON THE
STANDARDIZATION OF SAFETY AND PERFORMANCE TESTS
FOR ENERGETIC MATERIALS

CONFERENCE ROOM
SAMUEL FELTMAN BUILDING (3022)
US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NJ 07801
15-19 OCTOBER 1979

AGENDA

Monday, 15 October 1979

1000-1300 hrs	Registration - Building 3022 Foyer
1300 hrs	Introduction

- Welcome
- Announcements
- General description of meeting format and purpose

1330-1630 hrs	Review of Outline for a Standardization Manual

- Description and comments by national delegates on proposed outline and sub-division of task
- Agreement on interim outline for purpose of meeting

Tuesday, 16 October 1979

0830-0930 hrs	Formation of Discussion Groups in Accordance with Sub-Division of the Manual* and Assignment of Group Meeting Rooms (*Assumed to be only materials (interim qualification) tests

---

Coffee Breaks are scheduled each day at 1000 and 1500 hrs.

Tuesday, 16 October 1979 (Cont'd)

0930-1130 hrs	Meeting of Discussion Groups; Each Group Should: - Elect Chairman and Secretary Protem - Decide on Scope of Mandatory Tests to be included in their respective portion of the manual - Accept (protem) Specific Mandatory Test Proposals brought to meeting by delegates - Identify needs for additional mandatory test descriptions - List and accept (protem) specific proposals for supplementary tests
1130-1300 hrs	Lunch
1300-1630 hrs	Continue Group Discussions

Wednesday, 17 October 1979

0830-1000 hrs	Interim Report of Group Discussions
1000-1130 hrs	Continue Group Discussions
1130-1300 hrs	Lunch
1300-1630 hrs	Complete Group Discussions

Thursday, 18 October 1979

0830-1130 hrs	Receive Group Reports; Assemble First Draft of a Manual (based on accepted proposals and identified needs)
1130-1300 hrs	Lunch
1300-1630 hrs	Identify and Assign Responsibilities for Review and Completion of Final Draft of a Manual (responsibilities may be assigned in terms of national or international responsibility for individual sections of the manual)

Friday, 19 October 1979

0830-1130 hrs General Discussion of the Problem of Final- or Type-Qualification Tests of Explosives in Munitions

Future Plans and Milestones

APPENDIX C

POSSIBLE OUTLINE OF MANUAL

I. INTRODUCTION

Objective
Approach
Scope

II. METHODOLOGY

Terminology
Procedure
Qualification Criteria and Requirements

III. AUTHORITIES

IV. INTERIM QUALIFICATION TESTS

A. Safety Tests

B. Storability/Transportation Tests

C. Compatibility Tests

D. Physical Properties

E. Toxicity/Environmental Impact

F. Performance Tests

1. High Explosives

Primary
Booster
Main Charge
Liquid (Slurry or Fuel-Air)

2. Propellants

Gun
Mortar
Small Arms
Rocket
Liquid

3. Pyrotechnics

Illuminants
Decoys
Delays
Igniters
Incendiary
Flame
Training Munitions

V. FINAL QUALIFICATION

Outline requires discussions.

VI. REFERENCES

APPENDIX D
STANAG QUESTIONNAIRE

UNITED STATES
SENSITIVENESS AND EXPLOSIVENESS CHARACTERISTICS

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE	
	POWDER TESTS	CHARGE TESTS
THERMAL		
1. How easily does it ignite?		
2. How does it react when ignited?		
3. How does confinement affect the response when ignited?		
4. Is there a possibility of the charge size approaching the critical self heating value?		
ELECTRICAL		
5. How readily does it react to electric sparks?		
MECHANICAL		
6. How readily does it react to impact where trapped between hard surfaces, and what is the response?		
7. How readily is it sensitized by adventitious grit, and what is the response?		
8. How readily does it react to frictional impact and what is the response?		

SENSITIVENSSS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE	
	POWDER TESTS	CHARGE TESTS
MECHANICAL (Cont'd)		
9. How readily does it react to explosive shock and what is the response?		
10. How readily does it react to attact by high velocity fragments and what is the response?		
11. How readily does it react to high velocity impact and what is the response?		
12. How readily does it react to intrusion and what is the response?		

GREAT BRITAIN

PRIMARY EXPLOSIVES (Powder)

THERMAL	UK SAFETY TEST	SCC No3	UK CATEGORY
1.	5	3	Mandatory
2.	6	4	Mandatory
3.	Not relevant	-	Prescribed
4.	Not relevant	-	
ELECTRICAL			
5.	11	7	Mandatory
MECHANICAL			
6.	1 9	1 14	Mandatory Prescribed
7.	1 9	1 14	Optional Optional
8.	3 10 4	2 13 -	Mandatory Mandatory Optional
9.	Not relevant	-	
10.	Not relevant		
11.	Not relevant		
12.	12	-	Optional

No charge tests for primary explosives.

GREAT BRITAIN
PYROTECHNICS (Powder)

THERMAL	UK SAFETY TEST	SCC No 3	UK CATEGORY
1.	5	3	Mandatory
	6	4	Mandatory[1]
2.	7	5	Mandatory[2]
3.	A UK TNT Equivalency Test is Under Development		
4.	Not relevant	-	
ELECTRICAL			
5.	8	6	Mandatory
	11	7	Prescribed
MECHANICAL			
6.	1	1	Mandatory
7.	Not relevant	-	
8.	3	2	Mandatory
9.	A UK TNT Equivalency Test is Under Development		
10.			
11.			
12.			

[1] A more discriminating ignition test is desirable and under development

[2] A dust cloud in air test is desirable

Pyrotechnics Charges

No standard tests are carried out at present in the UK on pyrotechnic charges. However, with the advent of plastic bonded pyrotechnics there is a need for reappraisal.

GREAT BRITAIN

HIGH EXPLOSIVES AND BOOSTER EXPLOSIVES AND PROPELLANTS (Powder)

THERMAL	UK SAFETY TEST	SCC No3	UK CATEGORY
1.	5 6	3 4	Mandatory Mandatory
2.	7	5	Mandatory
3.	Not relevant	-	
4.	Not relevant		
ELECTRICAL			
5.	8	6	Mandatory
MECHANICAL			
6.	1 2	1 17	Mandatory Prescribed
7.	1	1	Prescribed
8.	3 4	2 -	Mandatory Prescribed
9.	14	18	Prescribed
10.	Not relevant	-	
11.	Not relevant	-	
12.	Not relevant	-	

GREAT BRITAIN
HIGH EXPLOSIVES AND BOOSTER EXPLOSIVES (Charges)

THERMAL	UK SAFETY TEST	SCC No3	UK CATEGORY
1.	20	-	Optional
	21	-	Prescribed
2.	33	25	Prescribed
3.	30	9	Prescribed
	31	10	Prescribed *
	19	-	Prescribed
	25	-	Prescribed
4.			
ELECTRICAL			
5.	Not relevant		
MECHANICAL			
6.	1	1	Prescribed
7.	21	-	Prescribed
	1	1	Prescribed
8.	24	16	Mandatory (main charge)
9.	13	11	Prescribed
	14	18	Prescribed
	15	22	Prescribed *
	16	23	Prescribed
	17	15	Prescribed
	18	-	Prescribed
	32	19	Prescribed
10.	26	21	Prescribed
	27	29	Prescribed *
11.	34	28	Prescribed
12.	22	-	Prescribed Main*
	23	24	Prescribed Charge

* It is mandatory that one of these prescribed tests is carried out.

GREAT BRITAIN
PROPELLANTS (Charges)

THERMAL	UK SAFETY TEST	SCC No3	UK CATEGORY	
1.	20	-	Optional	
	21	-	Prescribed	
	37	-	Optional	
2.	33	25	Prescribed	
3.	30	9	Prescribed	
	31	10	Prescribed	*
	19	-	Prescribed	
4.				
ELECTRICAL				
5.	Not relevant			
MECHANICAL				
6.	1	1	Prescribed	
7.	21	-	Prescribed	
	1	1	Prescribed	
8.	24	16	Prescribed	
9.	13	11	Prescribed	
	15	22	Prescribed	*
	16	23	Prescribed	
	17	15	Prescribed	
	18	-	Prescribed	
	32	19	Prescribed	
10. *	28	-	Optional	
	29	-	Optional	
11.	34	28	Prescribed	
12.	22	-	Prescribed	
	23	24	Prescribed	*

* It is mandatory that one of the prescribed tests is carried out.

GREAT BRITAIN
SENSITIVENESS AND EXPLOSIVENESS CHARACTERISTICS

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE POWDER TESTS	CHARGE TESTS
THERMAL		
1. How easily does it ignite?	Temperature of Ignition. Ignition by flash.	Minimum Energy of Ignition (by hot wire). Adiabatic compression tests.
2. How does it react when ignited?	Train test. Fuel fire test on boxed material.	Fuel fire test on boxed material.
3. How does confinement affect the response when ignited?	Sealed vessel tests.	Labset Test. Sealed vessel tests. Burning tube tests (DDT).
4. Is there a possibility of the charge size approaching the critical self heating value?		Heat flow calorimetry (plus DTA/DSC data).
ELECTRICAL		
5. How readily does it react to electric sparks?	Electric spark tests.	
MECHANICAL		
6. How readily does it react to impact where trapped between hard surfaces and what is the response?	Drop weight impact test. Ball and disc test.	Drop weight impact test on sample discs.
7. How readily is it sensitized by adventitious grit and what is the response?	Drop weight impact test with sandpaper or added grit.	Drop weight or impulse. Test with added grit.
8. How readily does it react to frictional impact and what is the response?	Mallet Test. Pendulum (emery paper) friction test. Rotary Friction Tests.	Oblique Impact (skid) Test.

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE	
	POWDER TESTS	CHARGE TESTS
MECHANICAL (Cont'd)		
9. How readily does it react to explosive shock and what is the response?		Shock Sensitivity and Shock Initiation Tests.
10. How readily does it react to attack by high velocity fragments and what is the response?		Fragment attack tests (on bare charges and model sections of warhead, rocket motors etc).
11. How readily does it react to high velocity impact and what is the response?		Filled projectile impact tests, e.g., Susan Test
12. How readily does it react to intrusion and what is the response?	Stab sensitiveness Test	Spigot Intrusion Tests

EXPLOSIVE SENSITIVENESS CHARACTERISTICS USED IN CEA/DAM				
Questions on sensitiveness properties	TESTS USED			
	granular and small scale	*	consolidate and charge	*
THERMAL				
1 - How easily does the material ignite ?	temperature of ignition	Q	induction by progressive heating	D
- What is the decomposition temperature ?	DTA DSC	Q	hot wire test	D
			ODTX	P
- What are the kinetics of decomposition ?	vacuum test	Q		
2 - How does the material react to elevated temperature over extended periods of time ?	induction time	Q	cook off tests	P
3 - How does the material react when ignited ?			combustion test	P
			fuel fire test	Q
4 - How does the material react to confinement when ignited?			Jabset test	P
5 - Is there a possibility of the charge size approaching a critical self heating value ?	none		none	
ELECTROSTATIC				
6 - How readily does the material react to electrostatic sparks ?	none		none	
* Q = qualified D = in development P = in project				

EXPLOSIVE SENSITIVENESS CHARACTERISTICS USED IN CEA/DAM

Questions on sensitiveness properties	TESTS USED: granular and small scale	*	TESTS USED: consolidate and charge	*
MECHANICAL				
7 - How readily does the material react to impact where trapped between hard surface and what is the response ?	Sorgues drop hammer	Q	11 kg drop hammer	Q
8 - How readily does the material sensitised by adventitious grit and what is the response ?	none		none	
9 - How readily does the material react to frictional forces and what is the response ?	BAM friction	Q	hot wire and impact vertical skid test pendulum skid test	D Q D
10 - How readily does the material react to explosive skock what is the response ?	small scale gap test turning corner test	D D	small scale gap test turning corner test	D D
11 - How readily does the material react to attack by high velocity fragments and what is the response ?	none		riffle bullet	F
12 - How readily does the material react to high velocity impact and what is the response ?			susan test lance maquette	D Q
13 - What is the boundary between initiation and non initiation for one dimensional shock wave stimuli ?	electric flyer foil	D	electric flyer foil	D
14 - How readily does it react to intrusion and what is the response ?			tool punch at high velocity	D
15 - How does the material react to machining operations and what is the response ?			dry drilling test	Q

CANADA

SAFETY

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE POWDER TESTS	CHARGE TESTS
THERMAL		
1. DTA. Temperature of ignition. Bickford fuse. Vacuum stability test.	Setback simulator (Adiabatic air gap compression).	
2. Train test.	-	
3. -	-	
4. -	Heat flow calorimeter DTA.	
ELECTRICAL		
5. Electric spark test.	Electric spark test.	
MECHANICAL		
6. Impact test (ROTTER).	Setback simulator.	
7. -	-	
8. CERL friction impact machine.	Skid test.	
9. -	L.S.G.T.	
10. -	Rifle bullet 30 cal.	
11. -	Setback simulator.	
12. -	-	
13. -	Flying plate test.	
14. -	-	

NORWAY

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE POWDER TESTS	CHARGE TESTS
THERMAL		
1. How easily does it ignite?	DTA, BAM steeltube test.	
2. At what temperature will exothermic reaction start?	DTA	
3. How does it react when ignited?	DTA, BAM steeltube test.	
4. How does it react to elevated temperatures over time?	DTA.	
5. How does confinement affect the response when ignited?	BAM, Steeltube test.	
6. Is there a possibility of the charge size approaching the critical self heating value.		
ELECTRICAL		
7. How readily does it react to electric spark?	Electric spark test.	
MECHANICAL		
8. How readily does it react to impact where trapped between hard surfaces and what is the response?	BAM impact test.	
9. How readily is it sensitized by adventitious grit and what is the response?	—	
10. How readily does it react to fricitonal forces.	All friction machine will be used in the future.	

11.	How readily does it react to explosive shock and what is the response?	Air Gap.
12.	How readily does it react to attack by high velocity fragments and what is the response?	Cylinder projectile test.
13.	How readily does it react to intrusion and what is the response?	Cylinder projectile test
14.	Temperature variations during mechanical testing:	BAM impact test.

MANDATORY TESTS

0	Minimum ignitor test	
1	BAM impact test	
2	BAM steeltube burning test	
3	DTA/TGA	done today
4	Cylinder projectile test	
5	Critical diameter determination	
6	Air gap	
7	ABL friction test	will be done
8	Spark test	from 1/1/80
9	BAM friction test	done today

SWEDEN

ALL EXPLOSIVES

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE: POWDER TESTS	CHARGE TESTS
THERMAL		
1. How easily does it ignite?	DTA/DSC/TGA. Temperature of ignition. Ignition by flash.	
2. How does it react when ignited?	Train test.	
3. How does confinement affect the response when ignited?	Vented vessel tests. (Setback tests).	Vented vessel tests. (Setback tests).
4. Is there a possiblity of the charge size approaching the critical self heating value?	DTA/DSC.	
ELECTRICAL		
5. How readily does it react to electric sparks?	Electrostatic spark tests.	
MECHANICAL		
6. How readily does it react to impact where trapped between hard surfaces and what is the response?	BAM drop weight impact test.	
7. How readily is it sensitized by adventitious grit and what is the response?	BAM drop weight impact test with sandpaper or added grit.	
8. How readily does it react to frictional impact and what is the response?	BAM friction test.	

9.	How readily does it react to explosive shock and what is the response?	Shock sensitivity tests.	Shock sensitivity and Shock initiation
10.	How readily does it react to attack by high velocity fragments and what is the response?	Flat projectile test	Flat projectile test
11.	How readily does it react to high velocity impact and what is the response?	-	-
12.	How readily does it react to intrusion and what is the response?	-	-

NETHERLANDS

1A. DTA

1B. Thermal Step Test

1C. Isothermal storage test. Adiabatic storage test.

1D. -

2. BAM - test. Thermal explosion test.

4. Isothermal storage test. Adiabatic storage test.

5. Bu Mines test.

6&7. BAM-test.

8. BAM-test.

9. NOL large scale gap test.

10.

11.

12.

13.

14.

GERMANY

PROPOSED MANDATORY

Number	Powder	Charge
1	Verpuffuns (flammenpendel)	-
2	Train test (only black powder)	-
3	Stahlhülsen-test	
4		
5	Electric spark test (only primary)	-
6	BAM-fall hammer Julius Peters (drop weight)	propellant disc
	BAM - Reidapparat (friction)	

UNITED STATES

PRIMARY EXPLOSIVES

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE: POWDER TESTS	CHARGE TESTS
THERMAL		
1. How easily does it ignite?	Expl. Temp (unconfined). Expl. Temp (confined) DTA/TGA.	
2. How does it react when ignited?	Burn test ODTY	
3. How does confinement affect the response when ignited?	Expl. Temp. (Henkin)	
4. Is there a possibility of the charge size approaching the critical self heating value.		
ELECTRICAL		
5. How readily does it react to electrostatic sparks?	BOM UK#7 Appr. Elect Conf Appr. Elect Navy Fixed Gap	N/A
MECHANICAL		
6. How readily does it react to impact where trapped between hard surfaces and what is the response?	BOM Impact PA ERL Ball drop	N/A
7. How readily is it sensitized by adventitious grit and what is the response?	ERL PA w/grit BOM w/grit Ball drop w/grit	N/A

8.	How readily does it react to frictional forces and what is the response?	PA Friction NOTS Friction BAM	N/A
9.	How readily does it react to explosive shock and what is the response?	Flyer plate Flyer foil	Flyer plate Flyer foil
10.	How readily does it react to attack by high velocity fragments and what is the response?		
11.	How readily does it react to high velocity impact and what is the response?	Flyer plate Flyer foil	Flyer plate Flyer foil
12.	How readily does it react to intrusion and what is the response?		
13.	What is the boundary between initiation and noninitiation for 1-D shock wave stimuli?		
14.	What is the effect of machining operation?		

UNITED STATES

MAIN CHARGE EXPLOSIVES

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE POWDER TESTS	CHARGE TESTS
THERMAL		
1. How easily does it ignite?	Expl. Temp. DTA/TGA.	
2. How does it react when ignited?	Burn test Bonfire	Burn test Bonfire
3. How does confinement affect the response when ignited?	Expl. Temp. ODTY	Cook-off test DDT
4. Is there a possibility of the charge size approaching the critical self heating value.		DTA/TGA/DSC
ELECTRICAL		
5. How readily does it react to electric sparks?	BOM UK#7 Conf. Appr. Elect. (DEN) Navy fixed gap.	
MECHANICAL		
6. How readily does it react to impact where trapped between hard surfaces and what is the response?	BOM impact PA ERL	Drop weight on pellets Large scale impact
7. How readily is it sensitized by adventitious grit and what is the response?	ERL impact w/sandpaper. PA w/grit BOM	Drop weight w/grit or sandpaper.
8. How readily does it react to frictional impact and what is the response?	PA friction NOTS friction BAM	Oblique test Skid

9. How readily does it react to explosive shock and what is the response?	Gap test Large Gap test Small Flyer plate Flyer foil
10. How readily does it react to attack by high velocity fragments and what is the response?	30 cal bullet 50 cal projectile Frag. Impact
11. How readily does it react to high velocity impact and what is the response?	Susan Flyer plate Gas gun Activator
12. How readily does it react to intrusion and what is the response?	Spigot

UNITED STATES

PROPELLANT

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE POWDER TESTS	CHARGE TESTS
THERMAL		
1. How easily does it ignite?		
2. How does it react when ignited?	Burn test Bonfire	Burn test Bonfire
3. How does confinement affect the response when ignited?	Explosion temp.	
4. Is there a possibility of the charge size approaching the critical self heating value?		
ELECTRICAL		
5. How readily does it react to electric spark?	BOM, UK#7 Conf. Appr. Elect (DEN) Navy fixed gap	
MECHANICAL		
6. How readily does it react to impact where trapped between hard surfaces and what is the response.	BOM impact PA ERL	
7. How readily is it sensitized by adventitious grit and what is the response?		
8. How readily does it react to frictional impact and what is the response?	PA friction NOTS friction BAM	

9. How readily does it react to explosive shock and what is the response?	Gap tests
10. How readily does it react to attack by high velocity fragments and what is the response?	
11. How readily does it react to high velocity impact and what is the response?	
12. How readily does it react to intrusion and what is the response?	

UNITED STATES

PYROTECHNICS

SENSITIVENESS AND EXPLOSIVENESS CHARACTERISTICS

SENSITIVENESS AND EXPLOSIVENESS PROPERTIES	EXAMPLES OF TESTS - SELECTED AS APPROPRIATE	
	POWDER TESTS	CHARGE TESTS

ADDITIONAL TESTS FOR SAFETY
SUBMITTED BY: Eric Olson, DARCOM Field Safety Activity

The following tests are required in the U.S. for the proper assignment of storage and transportation hazard classifications for energetic materials. However, they are not necessarily required for interim qualification for military use, and with one exception being the Thermal Stability Test, might not be considered "mandatory" for the proposed manual on standard qualification testing. On the other hand, it must be recognized that if a formulation developed in a foreign country is procured by the U.S. without this data, additional testing may be required prior to shipment. The tests are listed in the format of the UK "questions" on Sensitiveness and Explosiveness Properties. The test procedures are presented in TB 700-2 (now being published-latest available draft: March 1979). Each test may be regarded as a "charge" test as opposed to a "powder" test.

THERMAL

2. How does it react when ignited?	Ignition and Unconfined Burning Test

NEW

How does it react to elevated temperature over an extended period.	Thermal Stability Test

NOTE: This test should be regarded as "mandatory" for qualification since marked decomposition indicates that the material is DOT "Forbidden".

MECHANICAL

6. How readily does it react to impact and what is the response?	Bureau of Explosives drop weight test, or other drop weight test with reference material data.
9. How readily does it react to explosive shock and what is the response?	a. TB 700-2 Card Gap Test or other gap test with reference material data. b. No. 8 Blasting Cap Test

Single Package and Stock Detonation tests and External Fire Stock tests are performed on end items ("stores"). In some cases, data from such tests may be useful regarding bulk formulations which are boxed for transportation and storage. These are "optional" for qualification testing.

Recommendations apply only to HE (LLL, LASL)

DOE Recommendations for tests

QUESTION	APPROPRIATE TEST(S)	MANDATORY OR OPTIONAL
1. How easily does it ignite?	None suggested	Optional
1. What is decomp. temp.?	DTA, DSC, etc	Mandatory
2. What are kinetics of decomposition?	ODTX	Optional
3. How does it react when unconfined?	(TB 700-2) Unconfined burn test	Mandatory Optional
4. How does confinement afect response?	Cookoff test, temp to explosion, DDT	Optional
5. Critical self heating value?	ODTX, Henkin, temp. to explosion	Optional
6. Electrostatic sparks?	LASL approaching electrode (or equivalent)	Mandatory
7. Impact	Drop hammer	Mandatory
8. Impact w/grit	Drop hammer	Optional
9. Friction	Skid test	Mandatory
10. Explosive shock	Gap test	Optional
11. High Vel. Fragments	Projectile test	Optional
12. High Vel. Impact	Susan test	Optional
13. Shock Initiation	Wedge, electric flying foil	Optional
14. Intrusion tests	None suggested	
15. Machining tests	None suggested	

Table D-1

STABILITY TESTS:- REQUIRED, IN USE, ACCEPTABLE

Symbols.
- A - Test is considered to provide useful & relevant data
- U - Test is used by country indicated
- M - Test is mandatory in country indicated

Test No	Test	High Explosives					Propellants					Pyrotechnics					Primary Explosives				
		Canada	Germany	Netherlands	UK	US	Canada	Germany	Netherlands	UK	US	Canada	Germany	Netherlands	UK	US	Canada	Germany	Netherlands	UK	US
1	Vacuum Stability Test	U	U	U	U	M	A	A		A	M		A			M		A			M
2	Abel Heat Test (Potassium Iodide - Starch Test) Note: Germany uses & will accept this test for NG only						A	A	A	U	M										
3	Bergmann - Junk Test Note: Canada, Germany & UK comments apply to nitrocellulose only						A	U	A	U	A										
4	80°C Silvered Vessel Test						A	A		U	A										
5	Temperature of Ignition Test	A	U	A		M	A	U	A		A	A	A		A	A	A	U		[illegible]	[illegible]
6	65.5°C Surveillance Test						A	U		A	M										
7	NATO Test (STANAG 4117) (Gun propellants)						A	A	A	U	M										
8	Storage Trials at 50°C, 60°C & 80°C (Loss of stabiliser measured in propellants)	A					A	A	A	U	A	A					[illegible]	A		[illegible]	
9	Change in composition after aging in presence of moisture			A					A			A	A	A	U	A	A	A	A	U	A
10	90°C Surveillance Test (Thin Layer Chromatography)							U	A	A	M										
11	Exudation Note: Canada & UK acceptance subject to satisfactory method being provided	A	U		A	M		A			M										
12	DTA/DSC	A	A	A	A	A	A	A	A		A	A	A	A	A	A	A	A	A	A	A
13	U.S. Self Heating Test Note:- Test method not known to Netherlands & UK	A	A			M	A											A			M
14	Heat Flow Calorimetry	A	A	U		A	A	A	U	U	A		A	U		A					
15	Dutch Weighing Test							A	M	A	A										

Table D-2

STABILITY TESTS (SUPPLEMENTARY)

		HE	PROP	PYRO	PRIMARY
1	Taliani Test	+	+		
2	Methyl Violet Test		+		
3	90°C Weight Loss Test		+		
4	Small Vessel Test (80°C)		+		
5	Hansen Test (Denmark)		+		
6	TGA	+	+	+	+
7	80°C Surveillance Test		+		
8	Propellant Stabilizer Content (Depletion) Woolwich Test at 80°C & 95% RH		+		
9	Changing Viscosity of Nitrocellulose (Denmark)		+		
10	Chemiluminescence Tests	+	+		

Table D-3

STORABILITY TESTS:- MANDATORY, IN USE, ACCEPTABLE

Symbols:
- A - Test is considered to provide useful & relevant data
- U - Test is used by country indicated
- M - Test is mandatory in country indicated
- R - Required information for qualification

Test No	Test	High Explosives					Propellants					Pyrotechnics					Primary Explosives				
		Canada	Germany	Netherlands	UK	US	Canada	Germany	Netherlands	UK	US	Canada	Germany	Netherlands	UK	US	Canada	Germany	Netherlands	UK	US
1	Vacuum Stability Test	U	U	U	U	M	A	A		A	M		A			M		A			M
2	Abel Heat Test (Potassium Iodide Starch Test)						A		A	U	M										
3	65.5°C Surveillance Test						A	U	A	A	M										
4	NATO Test (STANAG 4117)						A	A	A	U	M										
5	Storage Trials at 50°C, 60°C, 80°C (Loss of stabiliser measured in propellants)	A					A	A	A	U	A	A					A			U	A
6	90°C Surveillance Test (Thin Layer Chromatography)						A	U		A	M										
7	Change in composition after ageing in presence of moisture			A					A			A	A	A	U	A		A	A	U	A
8	Heat Flow Calorimetry	A	A			A	A	A	U	U	A		A								
9	Exudation Test		U	R		M	R			R											
10	Cube Cracking Test		U			A	A	U	A	U	A										
11	Effect of Water	R		R	R		R	R	R	R		R	R	R	R	R			R	R	
12	Volatility	R	R	R	R	R	R	R	R	R	R	R		R	R	R	R		R	R	R
13	Hygroscopicity	R		R	R	R	R	R	R	R	R	R	R	R	R	R	R		R	R	R
14	Solubility (in water & other solvents as appropriate)	R		R	R	R	R		R	R	R	R		R	R	R	R		R	R	R
15	Occurrence of crystal modifications & other phase changes	R	R	R	R	R	R	R	R	R	R	R		R	R	R	R	R	R	R	R

Table D-4

COMPATIBILITY TESTS:- MANDATORY, IN USE, ACCEPTABLE

Symbols A - Test is considered to provide useful & relevant data
U - Test is used by country indicated
M - Test is mandatory in country indicated

Test No	Test	High Explosives					Propellants					Pyrotechnics					Primary Explosives				
		Canada	Germany	Netherlands	UK	US	Canada	Germany	Netherlands	UK	US	Canada	Germany	Netherlands	UK	US	Canada	Germany	Netherlands	UK	US
1	Vacuum Stability Reactivity Test	U	U	A	U	M	A	A	A	A	M	A	A	A		M	A	A	A		M
2	Propellant Stabiliser Loss						A	U	A	U	M										
3	Ageing followed by DTA/TGA/DSC as appropriate											A	A		U	A	A	A		U	A
4	Ageing followed by Chemical Analysis			A	A				A	A		A	A	A	U	A	A	A	A	U	A
	Supplementary Tests																				
5	DTA or DTA/TGA (Canada)	A	U	A		A	A	A	A		A	A	U	A		A	A	U	A		A
6	DSC		U	A		A		A	A		A		U	A		A		U	A		A
7	Silvered Vessel Test						A	A		U	A										

Under Development

Weight Loss Test 90°C/100°C for 40 hours

Heat Flow Calorimetry

Chemical Reactivity Test (Lawrence Livermore)

Chemiluminescence

APPENDIX E

SAFETY QUESTIONS TO BE ANSWERED

1.	How easily does the material ignite?	Optional
	(a) What is the decomposition temperature?	Mandatory
	(b) What are the kinetics of decomposition?	Optional
2.	How does material react to elevated temperatures (over extended periods of time)?	Mandatory
3.	How does the material react when ignited?	Mandatory
4.	How does the material react to confinement when ignited?	Optional
5.	Is there a possibility of the charge size approaching a critical self heating value?	Optional
6.	How readily does the material react to electrostatic sparks?	Mandatory
7.	How readily does the material react to impact where trapped between hard surfaces and what is the response?	Mandatory
8.	How readily is the material sensitized by adventitious grit and what is the response?	Optional
9.	How readily does the material react to frictional forces and what is the response?	Mandatory
10.	How readily does the material react to explosive shock and what is the response?	Optional
11.	How readily does the material react to attack by high-velocity fragments and what is the response?	Optional
12.	How readily does the material react during a high-velocity impact and what is the response?	Optional
13.	What is the boundary between initiation and noninitiation for one-dimensional shock wave stimuli?	Optional
14.	How readily does the material react to intrusion and what is the response?	Optional
15.	How does the material react to machining operations and what is the response?	Optional

DISTRIBUTION LIST

Commander
U.S. Army Armament Research and
Development Command
ATTN: DRDAR-TSS (5)
DRDAR-LCE (3)
DRDAR-GCL
Dover, NJ 07801

Administrator
Defense Technical Information Center
ATTN: Accessions Division (12)
Cameron Station
Alexandria, VA 22314

Director
U.S. Army Materiel Systems Analysis
Activity
ATTN: DRXSY-MP
Aberdeen Proving Ground, MD 21005

Commander
U.S. Army Armament Research and
Development Command
Weapons Systems Concepts Team
ATTN: DRDAR-ACW
APG, Edgewood Area, MD 21010

Commander/Director
Chemical Systems Laboratory
U.S. Army Armament Research and
Development Command
ATTN: DRDAR-CLJ-L
APG, Edgewood Area, MD 21010

Director
Ballistics Research Laboratory
U.S. Army Armament Research and
Development Command
ATTN: DRDAR-TSB-S
Aberdeen Proving Ground, MD 21005

Chief
Benet Weapons Laboratory, LCWSL
U.S. Army Armament Research and
Development Command
ATTN: DRDAR-LCB-TL
Watervliet, NY 12189

Commander
U.S. Army Armament Materiel
  Readiness Command
ATTN: DRSAR-LEP-L
Rock Island, IL 61299

Director
U.S. Army TRADOC Systems
  Analysis Activity
ATTN: ATAA-SL
White Sand Missile Range, NM 88002